Computing effects of impact on targets.

Army Research Lab (Douglas G. Lafon)

Techno-Warfare

Innovation and Military R&D

By JOSEPH I. LIEBERMAN

The Armed Forces now risk losing one of their premier advantages—a technological edge. Past decisions to counter numerically superior potential enemies with technological innovations have given the Nation the most formidable military in the world. But declining budgets combined with the legacy of the Cold War that pervades force structure and the research and development (R&D) enterprise is degrading our ability to remain dominant in the technology of warfare. Just as private corporations and foreign research firms are restructuring to capitalize on a fast-moving, growing array of technological breakthroughs and threats, military research and development must undergo an innovation revolution to maintain our technological dominance.

R&D Vulnerability

Over the last half century the Pentagon has funded the pre-award research of 58 percent of the Nation's Nobel prize winners in chemistry and 43 percent of laureates in physics. This reflects the striking relevance of defense research as an engine for national advances in technology.

The Honorable Joseph I. Lieberman represents the State of Connecticut in the U.S. Senate and is a member of the Armed Services Committee.

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Recently, however, DOD has been focused more and more on the urgent needs of today: readiness, modernization, military pay, and national missile defense. It has been unable to nurture sources of technological strength. Consequently, defense-sponsored research and development has fallen 30 percent over the last six years. The research portfolios of civilian agencies is simultaneously losing vigor. It is projected to drop another 15 percent in value over the next five years. Such declines are alarming, given that every plausible scenario of future warfare is premised on continuing technical superiority.

The innovation base, a traditional source of our military and economic strength, is eroding; yet we seem to not grasp the implications. I have yet to meet a strategist who recommends that we fight with only technological parity. But that is where we are headed. With a 30 percent decline in military research, another decrease slated for the next fiscal year, and projected cuts in Federally-funded civilian research and development, where will our technical superiority come from? Private sector research offers little help. Industry does conduct research and development, but it is largely (84 percent) and increasingly concentrated on the final stages of product development. When the military leverages research efforts from industry, it is leveraging only this stage. Industry obtains new ideas from the same pool of government-funded basic research. Almost three quarters of the papers cited in industrial patents, for example, draw on Federally-funded R&D programs. Both industry and the military rely on government-sponsored research for the intellectual groundwork of research and development.

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Technology as Linchpin

Dramatic advances in technology form the basis for not only a revolution in military affairs but a paradigm shift in the American way of war. Great strides in various disciplines, underpinned by exponential growth in the capability of communication and information systems, make military capabilities that seemed incredible just a few years ago not only possible but probable. Given the increasing speed and range of precision munitions coupled with strategic, operational, and tactical decisions based on near-real-time information it may be feasible in the future to overwhelm large but technologically inferior forces from the first moments of an attack. With advances in nuclear power, hydrolysis, and hydrogen storage promising virtually unlimited sources of on-site power, the Armed Forces may be able to operate indefinitely, free from long lines of supply and vulnerable support bases. Progress in robotics and miniaturization may make it possible to operate with fewer people and fight wars without concentrating forces, making military organizations less vulnerable.

The Legacy Dilemma

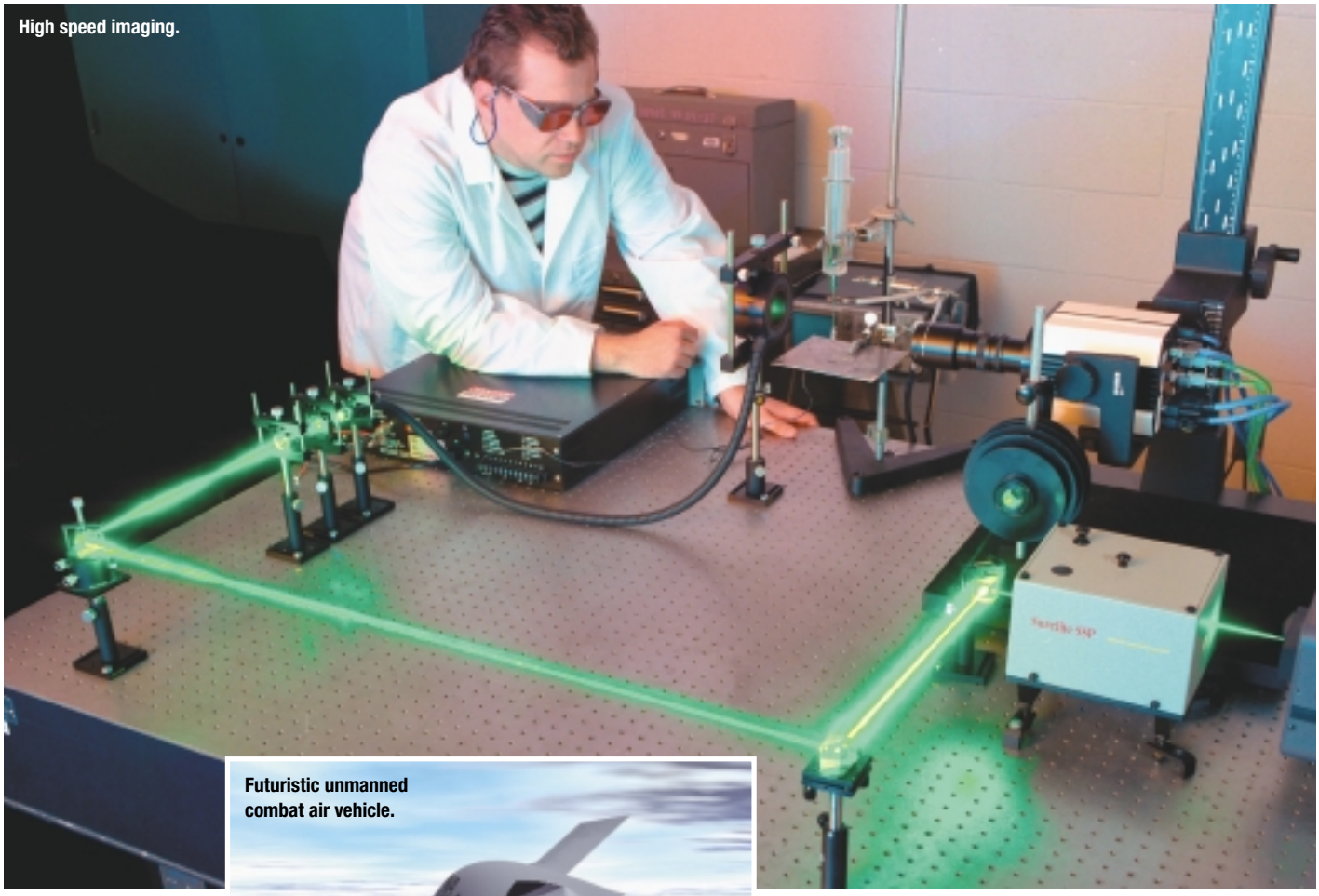
Unfortunately, the globalization of technology may make it equally easy for an enemy to do the same thing—in some ways easier because it may not have vested interests in maintaining large legacy forces. Today, the services spend 60 to 80 percent of their funding on force readiness and 20 to 40 percent on modernization for incremental improvements such as procurement, testing, and evaluation. Spending on science and technology is less than 2 percent of the overall DOD budget. Under currently proposed future year budgets, it will drop to 1 percent.

In time traditional land, sea, and air battles that justify current force structure and systems procurement will occupy a smaller part of the battlespace which must be covered. Meanwhile the lack of research and development will find us unprepared for conflicts that may reveal emerging threats in urban, space, electronic/information, nuclear, biological, and chemical warfare. As we struggle to prepare for combat on old and new battlefields, an enemy may focus its technological assets on only a few to asymmetrically exploit our vulnerabilities. Thus declining research funds, thinly spread across many threats and overwhelmingly obligated to present systems, will constitute a poor foundation for future readiness.

Senate Response

Working with colleagues in both parties I have been addressing issues of future readiness. Last year, Senators Jeff Bingaman, Rick Santorum, and I cosponsored a bipartisan sense of the Senate amendment calling for 2 percent annual increases in military research and development above the rate of inflation.

There is, however, more to be done. It is not enough to increase spending; we must shed the rationales and organizational structures of the Cold War for this enterprise and transform it into a fast-moving, well-integrated R&D machine that can seize the leading edge of techno-warfare. The time is now because in many ways the future is already here. The military systems of 2020 and 2030 will be based on the science of the year 2000 just as the high-tech weapons of today are the result of investments made by our predecessors in the 1960s and 1970s. So this year, joined



High speed imaging.

Army Research Lab (Douglas G. Lafon)

Futuristic unmanned combat air vehicle.

Boeing

by Senator Pat Roberts, we incorporated a defense innovation initiative in the Defense Authorization Bill for Fiscal Year 2000 to raise the priority assigned to military research and development.

Innovation Revolution

Our defense reform initiative is focused on three basic changes required for an innovation revolution. First, we must develop a new vision for research and development—define the destination. Second, we have to construct a new organizational structure to execute that vision. Third, we need innovative customers that will drive the R&D process to its full potential.

Defining the Destination. The 20 to 30 years needed for basic scientific discovery to evolve into a fielded system means that now is when we must understand the concepts of far future war and the capabilities we will want. Now is when we must define operational requirements to field the right weapons systems by 2020 or 2030.

Congress has directed both internal and external assessments to help define a clearer vision for the future. We view these assessments as important inputs into the congressionally mandated Quadrennial Defense Review (QDR). Every four years we will conduct a QDR to determine the threats we will face, the strategy we should adopt, and the force we should build.

Lacking clairvoyance, we should create an open conceptual architecture in the QDR process that frames potential future opportunities and threats and develops a picture of new

2d Marine Division (Scott A. Harwood)

Demonstrating new equipment, Urban Warrior.

technologies and systems to guide our R&D investments. At a minimum, the review should reveal whether the current decision to disinvest in many technological pathways will leave unacceptable windows of opportunity for technologically competent adversaries.

New Infrastructure. Once our vision of far future warfare and requirements is established, there must be a structure in place to implement it. The Defense Science Board has recommended that a third of the technologies pursued by DOD offer five to tenfold improvements in capabilities. Major organizational change will be required to achieve that goal. For example, the segregated and insulated components of the military R&D system cannot easily accommodate the pursuit of joint technologies, although such joint capabilities may have the broadest and arguably greatest potential for the Armed Forces.

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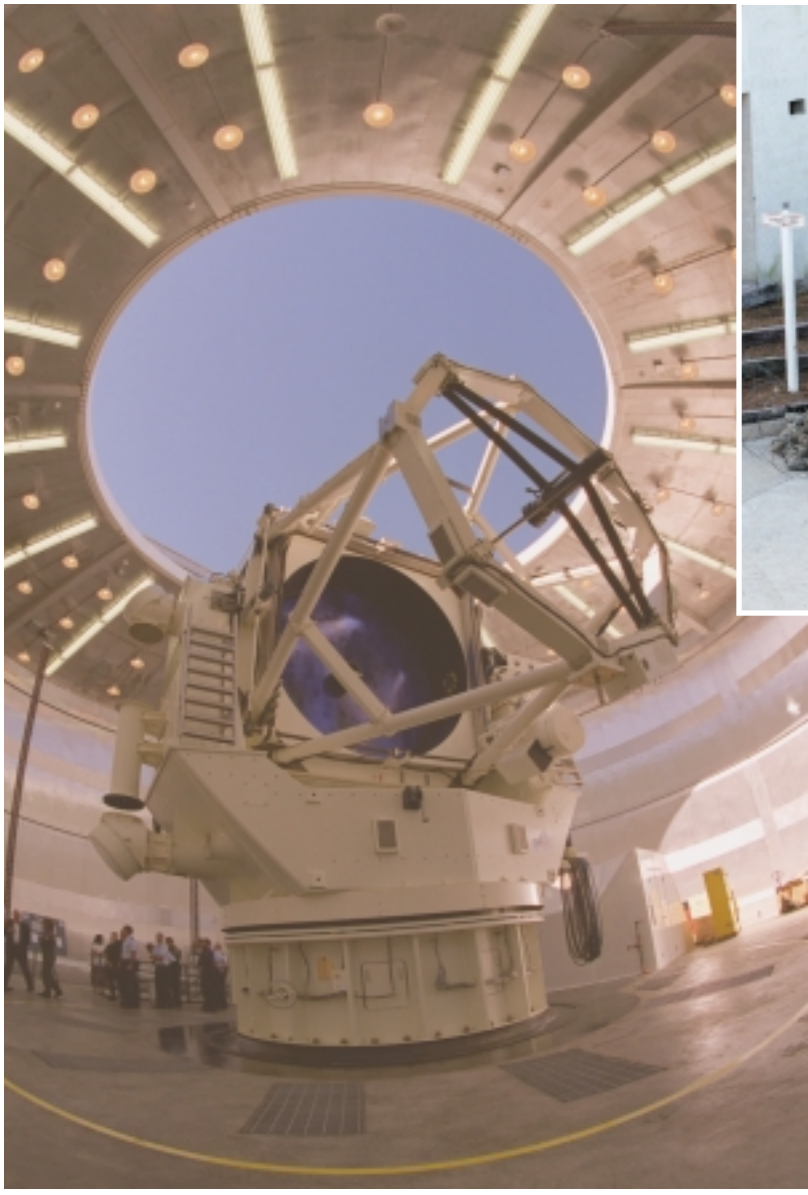
The stovepiped nature of the laboratory system is also ill-suited to the conduct of science in the information age. Great breakthroughs occur at the interface between scientific disciplines and organizations. The private sector takes advantage of temporary alliances between competitors and peers to develop technologies rapidly. The military must be able to use this system and leverage its potential. We must lower service and institutional barriers to allow joint technologies, innovations developed in other government laboratories, or ideas from the private sector to flow seamlessly into and across the R&D labs.

Laboratories must also become a culminating point for the minds of the brightest scientists to meet the demands of the most experienced warfighters. Out of this intense dialogue would come a better understanding of future warfare possibilities as well as technological breakthroughs needed to change warfighting. The current structure is not attracting and retaining the best scientific talent. The rigid DOD personnel system and the corresponding lack of performance-based compensation is causing the labs to hemorrhage talent to a more competitive and less bureaucratic private sector.

The R&D talent drain is compounded by longstanding DOD business practices that reflect a lack of connection between laboratories and their customer—the military. To facilitate a revolution in military research and development, we should repeal many restrictive lab regulations, encourage cross-fertilization with temporary assignment of personnel from other institutions, adopt modern business practices, nourish a vibrant dialogue between warfighters, scientists, and technologists, resolve overlaps and gaps within the existing laboratory system, and build a robust bridge between the R&D and acquisition pipelines.

Innovative Customers. We must also face the pressures that move the military away from innovation. The DOD system rewards laboratories with additional funding (contracts) when they dedicate themselves to maintenance and upgrades for existing systems. The laboratories receive no such incentive for striving towards visions of the far future. It is not surprising that the labs place their focus on the short term.

We require a defined customer for far future technologies. The ideal internal customer for revolutionary innovation would be the Joint Chiefs. But there are inadequate connections between the Joint Chiefs and service laboratories. Consequently, broadly sweeping strategies that capitalize on novel technologies are not rapidly incorporated into our organizations, doctrine, or systems.



DOD

Supporting space surveillance mission.

Special Purpose MAGTF X (Jason J. Bortz)

Joint amphibious mine clearing bulldozer.

Combat developers can be second innovative customers for research and development. At present the services only influence product development in the latter stages of the R&D cycle. Industry experience, however, has shown that if the customer and designers share in all product development decisions from the initial design, the degree of innovation is much higher, the product acceptance rate is much greater, and the pace of technological change is much faster. We should profit from these lessons and from bringing users and combat developers into the R&D process earlier.

Industry can also be a better innovative customer for military research and development. There are naturally constituent pressures applied by the industrial half of the military-industrial complex which are usually focused on legacy systems. Because no risk is involved in continued production of established systems, firms are virtually guaranteed profits. Designing a truly innovative system risks substantial loss if the concept does not work or is not acquired by DOD. The lack of an innovation profit driver for industry translates into an intense lobbying effort on Capitol Hill aimed squarely at preserving yesterday's systems. Substantially higher profit levels should be set by the Pentagon for the development of innovative systems than for the ongoing production of legacy systems.

The arms race that characterized the late 20th century will be replaced by a race in military technology in the decades ahead. Rather than amassing even larger inventories of conventional weapons, as occurred during the Cold War, we should concentrate on building fewer but rapidly evolving and specialized weapons systems. Revolutionizing the military R&D system to prepare for techno-warfare will be hard, but we must do so to guarantee our military superiority in the politically unstable, technologically sophisticated years ahead. **JFQ**